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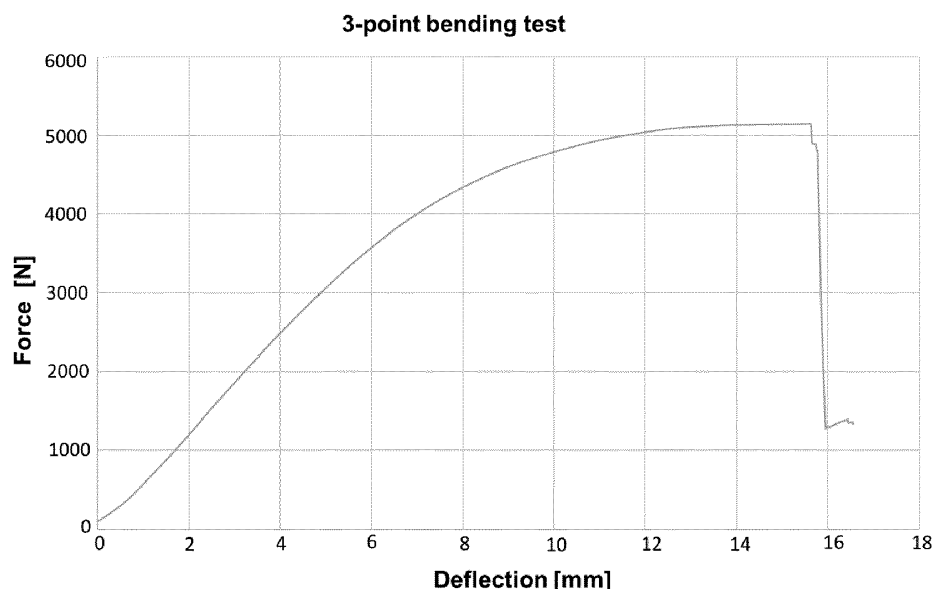
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(54) **ROD-BASED WOOD MATERIALS**

(57) Wood is becoming an increasingly important building material due to its renewability and CO₂ storage capacity. This results in high demand of the dominantly used wood species (e.g. spruce, pine). At the same, the share of hardwood species, which are far less utilized in the construction sector, is continuously increasing in central European forests and in particular spruce monocultures are destroyed by draught and bark beetles, due to climate changes. Hence in the near future new wood based products are needed, since common products like

Glulam and cross-laminated timber are predominantly based on the softwood species currently under pressure. Moreover, the material yield in saw timber production is very low for softwoods (~60%) and is even lower for hardwoods. The invention is reviving the traditional method for shingle production transferring it in the context of wood based products. This is a non-cutting process, which makes use of the easy fissility of wood parallel to the grain. In contrast to shingle production it serves for the production of up to ~1 m rods in a two-step process.

Fig. 5



Description

[0001] The present invention relates to a method for the production of wood rods for the fabrication of high performance wood-based products.

Background of the Invention

[0002] Wood is becoming an increasingly important building material due to its renewability and CO₂ storage capacity. This results in high demand of the dominantly used wood species (e.g. spruce, pine (in Europe)). At the same time, the share of hardwood species, which are far less utilized in the construction sector, is continuously increasing in central European forests and in particular spruce monocultures are destroyed by draught and bark beetles, due to impacts of climate change. Hence in the near future new wood based products are needed, since common products like Glulam and cross-laminated timber are predominantly based on the softwood species currently under pressure. Besides the demand in terms of timber provision also the problem of efficient use of the wood material calls for new inventions.

[0003] The prior art (WO 2012042027 A1) describes a method for the production of a wood composite with reduced density and lower weight but without loss in rigidity and strength. The method for the production of the wood composites includes the production of macro fibres which are aligned in a mould, covered with a glue and pressed together in a press giving the wood composite product. The glue is foamed up and surrounds the macro fibres. The macro fibres are produced through a cutting process of the tree.

[0004] In Switzerland, roughly only 60% of a processed stem finally ends in sawn timber and for the rest of the material secondary use needs to be considered (e.g. particle boards, cardboard). Hence, the invention for a new wood based product should be based on a non-cutting process for wood element production.

[0005] Based on the above-mentioned state of the art, the objective of the present invention is to provide means and methods to produce a high performance wood product, based on a more efficient use of the wood material and more diverse use of wood species. This objective is attained by the subject-matter of the independent claims of the present specification, with further advantageous embodiments described in the dependent claims, examples, figures and general description of this specification.

Summary of the Invention

[0006] A first aspect of the invention relates to a method for the production of a densified wood product comprising

- a. provision of a wood material, splitting parallel to the grain, yielding split wood rods,
- b. a production step, wherein the split wood rods are being placed into a mould, contacting a binder and

the split wood rods are being pressed against said mould in a pressing step, yielding said densified wood product.

[0007] A second aspect of the invention relates to a densified wood comprising split wood rods, wherein the split wood rods are characterised in that they are raw and exactly aligned with the fibre direction (no cut fibres).

Terms and definitions

[0008] For purposes of interpreting this specification, the following definitions will apply and whenever appropriate, terms used in the singular will also include the plural and vice versa. In the event that any definition set forth below conflicts with any document incorporated herein by reference, the definition set forth shall control.

[0009] The terms "comprising," "having," "containing," and "including," and other similar forms, and grammatical equivalents thereof, as used herein, are intended to be equivalent in meaning and to be open-ended in that an item or items following any one of these words is not meant to be an exhaustive listing of such item or items, or meant to be limited to only the listed item or items. For example, an article "comprising" components A, B, and C can consist of (i.e., contain only) components A, B, and C, or can contain not only components A, B, and C but also one or more other components. As such, it is intended and understood that "comprises" and similar forms thereof, and grammatical equivalents thereof, include disclosure of embodiments of "consisting essentially of" or "consisting of."

[0010] Where a range of values is provided, it is understood that each intervening value, to the tenth of the unit of the lower limit, unless the context clearly dictates otherwise, between the upper and lower limit of that range and any other stated or intervening value in that stated range, is encompassed within the disclosure, subject to any specifically excluded limit in the stated range. Where the stated range includes one or both of the limits, ranges excluding either or both of those included limits are also included in the disclosure.

[0011] Reference to "about" a value or parameter herein includes (and describes) variations that are directed to that value or parameter per se. For example, description referring to "about X" includes description of "X."

[0012] As used herein, including in the appended claims, the singular forms "a," "or," and "the" include plural referents unless the context clearly dictates otherwise.

[0013] The term *hardwood species* in the context of the present specification relates to wood from angiosperm trees, including ash, hornbeam, poplar, willow, basswood, birch, beech, buckeye, chestnut, hazel, walnut, elm, oak, maple, alder, plane tree, balsa, eucalyptus, paulownia.

[0014] The term *softwood species* in the context of the present specification relates to wood from gymnosperm trees, including cypress, Douglas-fir, fir, hemlock, larch,

pine, spruce, yew, and cedar.

[0015] The term *radial board* in the context of the present specification relates to the product of the initial splitting step, wherein these boards are irregularly shaped, elongated boards, which were split off the tree trunk segment along its grain.

[0016] The term *wood rod* in the context of the present specification relates to the product of additional splitting steps, wherein these wood rods are elongated rods of certain dimensions, which were split off the radial boards along its grain.

[0017] The term *ply assembly* in the context of the present specification relates to two or more layers of wood rods added on top of each other, wherein each additional ply is rotated through 90° compared to the previous layer.

[0018] The term *aspect ratio* in the context of the present specification relates to the ratio of length/width of a wood rod element.

[0019] The term *raw* in the context of the present specification relates to any wood material, including wood rods, not being sawn and processed so that no cutting surface and no truncated fibres are present.

Detailed Description of the Invention

[0020] A first aspect of the invention relates to a method for the production of a densified wood product comprising

a. provision of a wood material, splitting parallel to the grain, yielding split wood rods,

b. a production step, wherein the split wood rods are being placed into a mould, contacting a binder and the split wood rods are being pressed against said mould in a pressing step, yielding said densified wood product.

[0021] In certain embodiments, the wood material is split into radial boards in an initial splitting step.

[0022] The radial boards are split off a mostly debarked tree trunk segment along the grain of the tree similar to the traditional production of wood shingles. The way of splitting the radial boards off the tree trunk results in obtaining clean and raw radial boards.

[0023] In certain embodiments, the radial boards are split into wood rods in further splitting steps.

[0024] Each radial board is split along the grain into several wood rods. Equally to the radial boards, the splitting processes result in raw, clean wood rods. Furthermore, the rod's fibre are exactly aligned with the fibre direction (no cut fibres) as they are split along the grain, which results in better properties of the product.

[0025] Contrary to sewing processes to obtain wood pieces, the splitting technique allows for an efficient use of the full tree trunk without losing potential wood product e.g. in sawdust and side products.

[0026] In certain embodiments, the split wood rods are

characterised in that the width is 3 mm to 25 mm, particularly 5 mm to 20 mm, more particularly 8 mm to 15 mm.

[0027] In the splitting process, a thicker wood rod is more stable towards breakings than a thinner rod, so that longer wood rods can be produced if their width is between 5 mm to 25 mm.

[0028] In certain embodiments, the split wood rods are characterised in that the height is 3 mm to 25 mm, particularly 5 mm to 20 mm, more particularly 8 mm to 15 mm.

[0029] In certain embodiments, the split wood rods are characterised in that the length is 50 cm to 100 cm.

[0030] Wood rods with a length of around 100 cm have better mechanical performance in the pressed wood product due to a higher length and a higher aspect ratio.

[0031] In certain embodiments, the split wood rods are processed straight or curved.

[0032] For example the tree trunks contains tight knots inside the trunk resulting in irregular growing of the wood and thus curved wood rods when split.

[0033] In certain embodiments, the aspect ratio of the wood rods is around 80 to 1.

[0034] In certain embodiments, the rods are dried.

[0035] The split wood rods are dried in advance to the pressing step, wherein the drying is performed according to common procedures known by the person skilled in the art (see a).

[0036] In certain embodiments, the densified wood product is produced in the production step, wherein the wood rods are placed in a mould, contacted with a binder and pressed against the mould in a pressing step, or are continuously processed as known for fibre- or particle board production.

[0037] The production and pressing step are performed according to common procedures known by the person skilled in the art (see b).

[0038] In certain embodiments the binder, contacting the split wood rods, is polymer based and/or mineral based.

[0039] In certain embodiments the binder is selected from starch, tannins, micro fibrillated cellulose (MFC), nanocrystalline cellulose (NCC), methylcellulose, polyethylene polymers (PE), polypropylene polymers (PP), polymethylmethacrylate polymers (PMMA), polylactic acid polymers (PLA), epoxy polymers, melamine urea formaldehyde polymers (MUF), phenol-resorcinol-formaldehyde (PRF), polyurethanes (PUR), urea formaldehyde polymers (UF), cement, ceramic or gypsum.

[0040] In certain embodiments, the binder is selected from melamine urea formaldehyde polymers (MUF), phenol resorcinol formaldehyde (PRF), polyurethane (PUR), or cement.

[0041] In certain embodiments, the binder is bio-based and recyclable.

[0042] The use of bio-based and recyclable binders will result in a more sustainable, ecological and healthier fabrication of wood products.

[0043] In certain embodiments, the split wood rods are ordered in said mould in the same direction or in ply as-

semblies.

[0044] A uniform alignment of the wood rods leads to a densified wood product with higher mechanical properties in the direction of alignment (Fig. 5).

[0045] In certain embodiments, the densified wood product is a wood board or a wood beam, wherein the wood board or beam is straight or curved.

[0046] Depending on the slenderness of the wood rods, the wood rods can be shaped into curved wood boards. The higher the slenderness, the easier they can be shaped. Fabrication of straight as well as curved wood products allow for a more versatile spectrum of use.

[0047] A second aspect of the invention relates to a densified wood product comprising split wood rods, wherein the split wood rods are characterised in that they are raw and exactly aligned with the fibre direction (no cut fibres).

[0048] The use of cleanly split wood rods characterised by a surface and ideal fibre orientation results in a densified wood product with similar or higher strength than wood products from sawn wood.

[0049] In certain embodiments, the densified wood product, comprising split wood rods, wherein the split wood rods are characterised in that the width is 8 mm to 15 mm and the height is 8 mm to 15 mm.

[0050] In certain embodiments, the densified wood product, comprising split wood rods, wherein the split wood rods are characterised in that the length is 50 to 100 cm

[0051] In certain embodiments, the densified wood product is characterised in that the content of split wood rods from one or more hardwood species is 51% to 100%, particularly 70 % to 100%.

[0052] The use of an increased amount of wood hardwood species makes the densified product be more aligned with healthy and more sustainable forests of the future. Some hardwood species are not as endangered by climate change and draught as commonly used softwood species so that they provide a high quality alternative for wood products used in construction.

Description of the Figures

[0053]

Fig. 1 shows a side view of radial boards of ash wood after the initial splitting step.

Fig. 2 shows a side view of the wood rods of ash wood after further splitting of the radial boards.

Fig. 3 shows wood rods of spruce assembled in a mould before adding a binder and pressing.

Fig. 4 shows the cross-section of a densified wood product consisting of spruce rods after pressing it to a height of -28 mm and cutting into a beam of ~50mm width.

Fig. 5 shows force deflection curve of a densified wood product sample produced from split spruce wood rods and MUF resins, wherein the spruce wood rods are optimally aligned. The specimen with a density of 676 kg/m³ reached a bending strength of 85.5 MPa and a Young's modulus of 10400 MPa

Examples

Example 1: Production of wood rods

[0054] Wood rods are split in a two-step process from stem segments. The length of the stem segment determines the length of the rods. At first radial boards are split along the radial direction (along the rays). Afterwards, rods are produced by splitting the radial boards in the tangential direction. Hydraulic splitting devices, as used for the industrial shingle production, can be applied for the splitting.

Example 2: Production of the densified wood product

[0055] Rods with a moisture content of -8-12 % are aligned in parallel and layered in a mould and MUF resin is added to each layer. The composite is pressed at ambient temperature until the resin has cured. Density of the composites can be adjusted by the applied pressure.

Example 3: Three-point bending test to measure mechanical properties of the densified wood product

[0056] A specimen, produced from spruce wood rods bound with MUF (length: 503 mm width -48 mm, height -28 mm), was loaded in a standard 3-point bending test. The specimen with a density of 676 kg/m³ reached a bending strength of 85.5 MPa and a Young's modulus of 10400 MPa.

Example 4: Application of densified wood

[0057] Such produced wood-based products can be used as beams (such as Parallam) or as panel elements in flat or curved shape.

List of references

[0058]

a) Trübswetter T. (2006) Holztrocknung. Hanser Fachbuchverlag, ISBN 3-446-40477-5

b) Paulitsch M., Barbu, M.C. (2015) Holzwerkstoffe der Moderne. DRW Verlag Weinbrenner GmbH & Co. KG, ISBN 978-3-87181-891-2

Claims

1. A method for the production of a densified wood product, comprising
 - a. provision of a wood material, splitting parallel to the grain, yielding split wood rods,
 - b. a production step, wherein the split wood rods are being placed into a mould, contacting a binder and the split wood rods are being pressed against said mould in a pressing step, yielding said densified wood product.
2. The method according to claim 1, wherein the wood material is split into radial boards in an initial splitting step.
3. The method according to any of the preceding claims, wherein the radial boards are split into wood rods in further splitting steps.
4. The method according to any of the preceding claims, wherein the split wood rods are **characterised in that** the width is 3 mm to 25 mm, particularly 5 mm to 20 mm, more particularly 8 mm to 15 mm and/or the height is 3 mm to 25 mm, particularly 5 mm to 20 mm, more particularly 8 mm to 15 mm.
5. The method according to any of the preceding claims, wherein the split wood rods are **characterised in that** the length is 50 to 100 cm.
6. The method according to any of the preceding claims, wherein the aspect ratio of fibres to wood rods is around 80 to 1.
7. The method according to any of the preceding claims, wherein the production step is provided with a mix of split wood rods from different softwood and/or hardwood species.
8. The method according to any of the preceding claims, wherein the binder contacting the split wood rods, is polymer based and/or mineral based, particularly polymer based.
9. The method according to claim 8, wherein the binder is selected from starch, tannins, micro fibrillated cellulose (MFC), nanocrystalline cellulose (NCC), methylcellulose, polyethylene polymers (PE), polypropylene polymers (PP), polymethylmethacrylate polymers (PMMA), polylactic acid polymers (PLA), epoxy polymers, melamine urea formaldehyde polymers (MUF), phenol-resorcinol-formaldehyde (PRF), polyurethanes (PUR) or urea formaldehyde polymers (UF), cement, ceramic or gypsum, more particularly from melamine urea formaldehyde polymers (MUF), phenol resorcinol formaldehyde (PRF), polyurethane (PUR), cement, or gypsum.
10. The method according to any of the preceding claims, wherein all split wood rods are ordered in said mould in the same direction or in ply assemblies.
11. The method according to any of the preceding claims, wherein the densified wood product is a wood board or a wood beam and wherein the wood board or beam is straight or curved.
12. A densified wood product, in particular produced by the method according to claims 1 to 11, comprising split wood rods, wherein the split wood rods are **characterised in that** the width is 8 mm to 15 mm and the height is 8 mm to 15 mm.
13. The densified wood product, in particular produced by the method according to claims 1 to 11, comprising split wood rods, wherein the split wood rods are **characterised in that** the length is 50 to 100 cm.
14. A densified wood product in particular produced by the method according to claims 1 to 11, comprising split wood rods, wherein the split wood rods are **characterised in that** they are raw.
15. The densified wood product according to claim 13, wherein the densified wood product is **characterised in that** the content of split wood rods from one or more hardwood species is 51% to 100%, particularly 70% to 100%.

Fig. 1

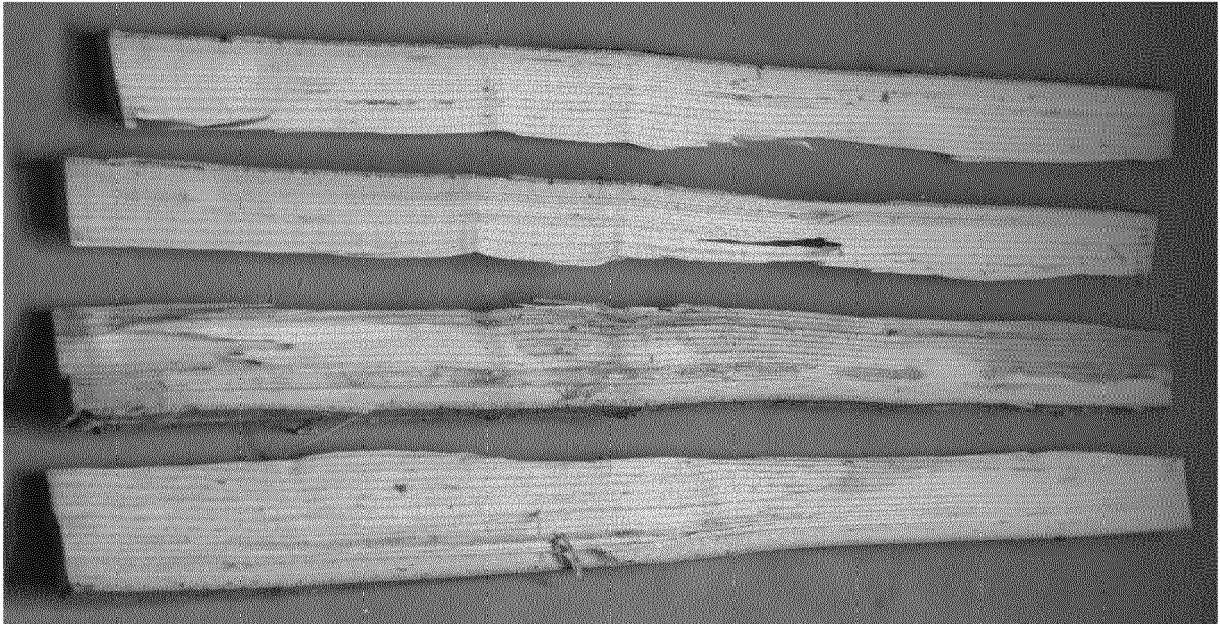


Fig. 2

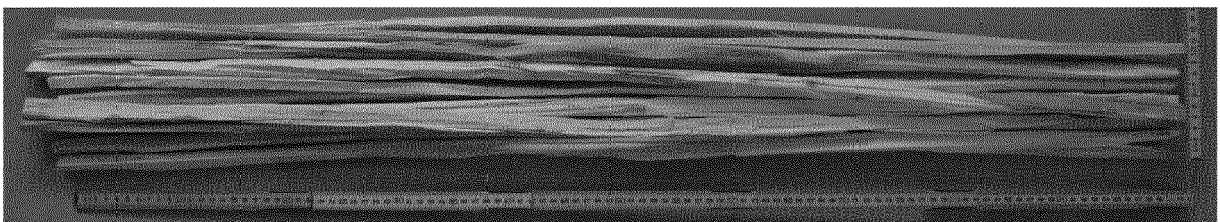


Fig. 3



Fig. 4

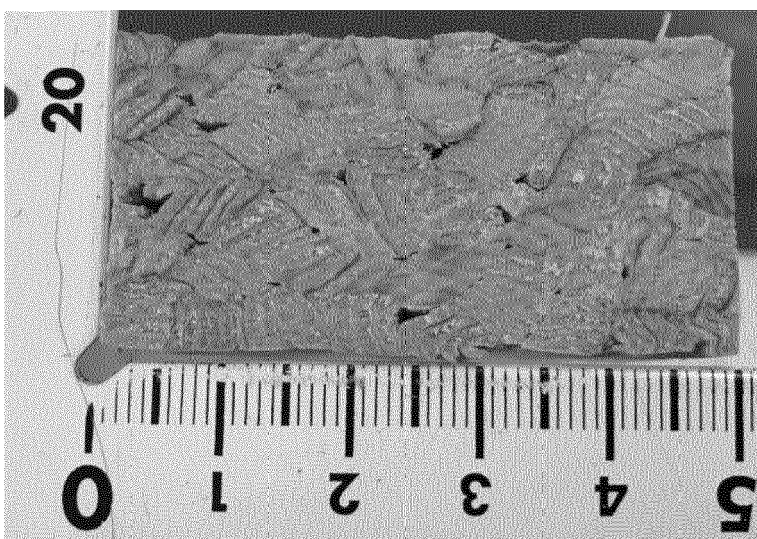
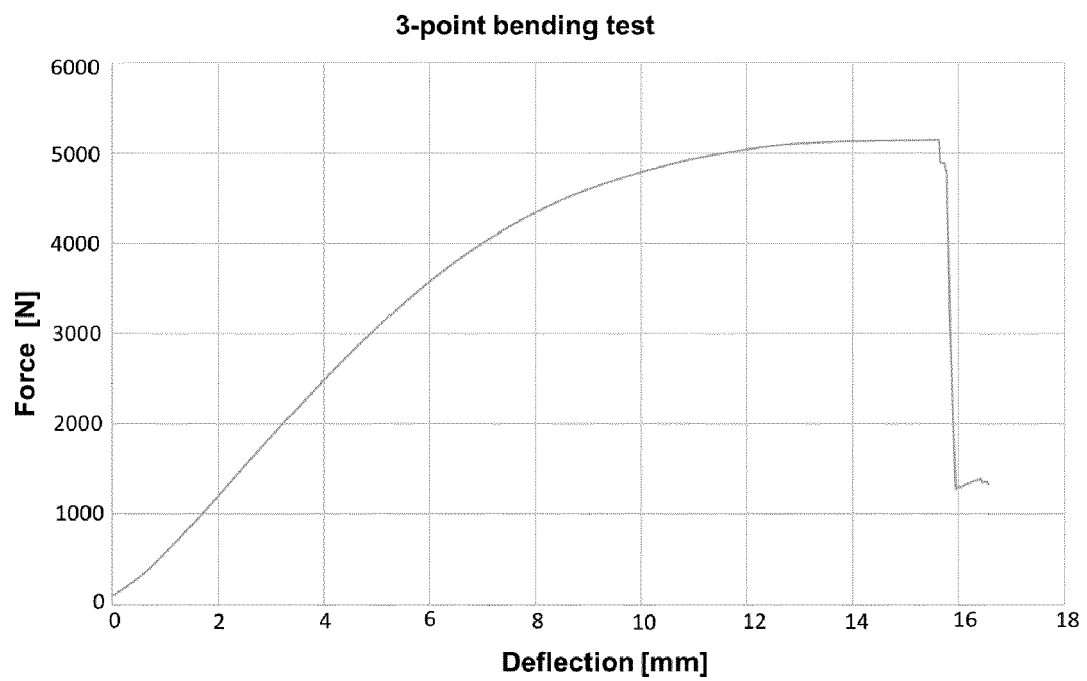


Fig. 5





EUROPEAN SEARCH REPORT

Application Number

EP 22 17 6100

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	EP 0 259 069 A2 (MAC MILLAN BLOEDEL LTD [CA]) 9 March 1988 (1988-03-09) * claims 1,10; figures 1,2,4,6 * * column 3, paragraph 1 * * column 6, paragraph 4 * * column 5, paragraph 5 * * claims 3,6 * * column 7, paragraph 4 * -----	1-15	INV. B27L7/00 B27N3/18 B27N1/00 B27N5/00 B27N3/02
X	EP 3 543 000 A1 (EMPA EIDGENOESSISCHE MAT & FORSCHUNGSANSTALT [CH] ET AL.) 25 September 2019 (2019-09-25) * paragraphs [0003], [0036]; claim 1; figures 1-3,5 * -----	1-15	
X	US 4 711 689 A (COLEMAN JOHN D [AU]) 8 December 1987 (1987-12-08) * abstract; claims 1,6; figures 2,3 * -----	1-15	
			TECHNICAL FIELDS SEARCHED (IPC)
			B27L B27M B27N
The present search report has been drawn up for all claims			

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Place of search

The Hague

Date of completion of the search

14 November 2022

Examiner

Baran, Norbert

CATEGORY OF CITED DOCUMENTS

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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO.

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15

20

25

30

35

40

45

50

55

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0259069 A2	09-03-1988	AT 83190 T	15-12-1992
		AU 608237 B2	28-03-1991
		CA 1281528 C	19-03-1991
		CN 87106342 A	13-04-1988
		DE 3782990 T2	29-04-1993
		EP 0259069 A2	09-03-1988
		ES 2106009 T3	01-11-1997
		FI 873811 A	04-03-1988
		JP 2527761 B2	28-08-1996
		JP S63107507 A	12-05-1988
		NZ 221605 A	26-02-1991
EP 3543000 A1	25-09-2019	AT 523035 A2	15-04-2021
		DE 112019001411 T5	03-12-2020
		EP 3543000 A1	25-09-2019
		WO 2019180006 A1	26-09-2019
US 4711689 A	08-12-1987	CA 1232728 A	16-02-1988
		DE 3486310 T2	18-05-1995
		EP 0196299 A1	08-10-1986
		EP 0355858 A2	28-02-1990
		GB 2177709 A	28-01-1987
		GB 2194243 A	02-03-1988
		JP 2509063 B2	19-06-1996
		JP H0544322 B2	06-07-1993
		JP H05329812 A	14-12-1993
		JP S61500481 A	20-03-1986
		NZ 210302 A	12-02-1988
		SE 458347 B	20-03-1989
		SE 458348 B	20-03-1989
		US 4711689 A	08-12-1987
		ZA 849186 B	31-07-1985

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- WO 2012042027 A1 **[0003]**

Non-patent literature cited in the description

- **TRÜBSWETTER T.** Holztrocknung. Hanser Fachbuchverlag, 2006 **[0058]**
- **PAULITSCH M. ; BARBU, M.C.** Holzwerkstoffe der Moderne. DRW Verlag Weinbrenner GmbH & Co. KG, 2015 **[0058]**